

Nervous System Lab Supplemental Guide

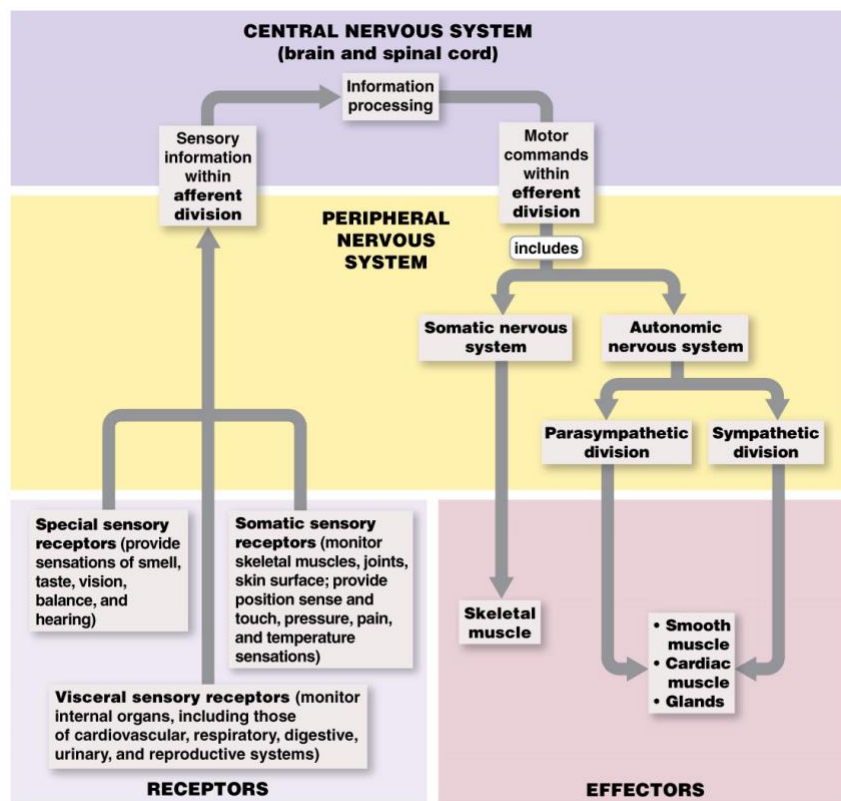
1. Overview of the Nervous System

A. The Nervous System is Organized into the Central Nervous System (CNS) and the Peripheral Nervous System (PNS)

- I. The central nervous system consists of the brain and spinal cord which are both responsible for integrations
- II. The peripheral nervous system consists of sensory and motor neurons that are responsible for transmitting information to and from the CNS.

B. The Nervous System Performs Sensory, Integrative, and Motor Functions

- I. Sensory function
 - a) detect external or internal stimuli
- II. Integrative function
 - a) Processing sensory information coming in
- III. Motor function
 - a) Information from CNS is sent to effectors like muscle and glands to elicit an action

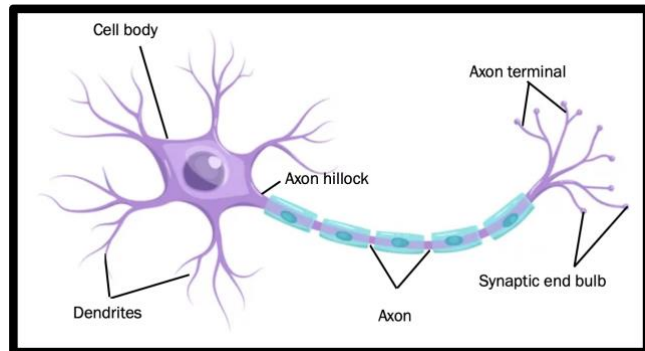


2. Cells of the Nervous System

A. Neurons Are Responsible for the Main Functions of the Nervous System

I. Components of a neuron and other specializations of structure

- a) Dendrites – input region; stimulated by environmental changes or the activities of other cells
- b) Cell body – integrative region; contains the nucleus, mitochondria, ribosomes, and other organelles and inclusions
- c) Axon – output conduction zone; conducts nerve impulse (action potential) toward synaptic terminals
- d) Axon hillock – connection between cell body and axon (anatomical term)
- e) Trigger zone – where the action potential is generated
- f) Axon terminals – terminal branch of an axon that ends with a synaptic end bulb.
- g) Synaptic end bulb - expanded distal end of an axon terminal where synaptic vesicles filled with neurotransmitters are located; also called a terminal bouton.



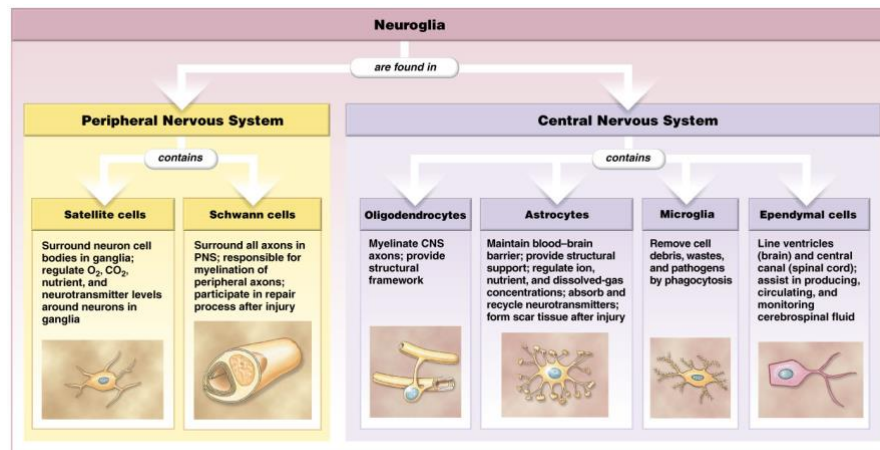
II. Functional classes of neurons

- a) Sensory (afferent) – a neuron whose axon carries sensory information from the peripheral nervous system toward the central nervous system.
- b) Motor (efferent) – a neuron whose axon carries motor commands from the central nervous system toward effectors.
- c) Interneuron – neurons inside the central nervous system that are interposed between sensory and motor neurons.

B. Neuroglia Provide Physical, Nutritional, and Metabolic Support to Neurons

I. Neuroglia of the CNS

- a) Astrocytes – are the largest and most numerous glial cells. Their functions include maintaining the ionic composition around neuronal tissue; maintaining the blood-brain barrier; creating a three-dimensional framework for the central nervous system; performing repairs in damaged neuronal tissue; guiding neuronal development and migration.
- b) Oligodendrocytes – resembles astrocytes only in that they both possess slender cytoplasmic extensions. However, oligodendrocytes have smaller cell bodies and fewer and shorter cytoplasmic processes. Form myelin sheath along the entire length of a myelinated axon within the CNS.
- c) Microglia – smallest of the glial cells. Provide immune function for the CNS by engulfing cellular debris and waste products.
- d) Ependymal cells – Line ventricles of the brain and central canal of the spinal cord. produce and circulate cerebrospinal fluid (CSF)



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II. Neuroglia of the PNS

- a) Schwann cells – provides myelination in the PNS and help repair in case of injury
- b) Satellite cells – support neuronal cell bodies in the dorsal root ganglia

C. Myelination Increases the Speed of Action Potential Conduction

Damaged Neurons Have a Limited Ability to Repair Themselves

3. Spinal cord

- Protection

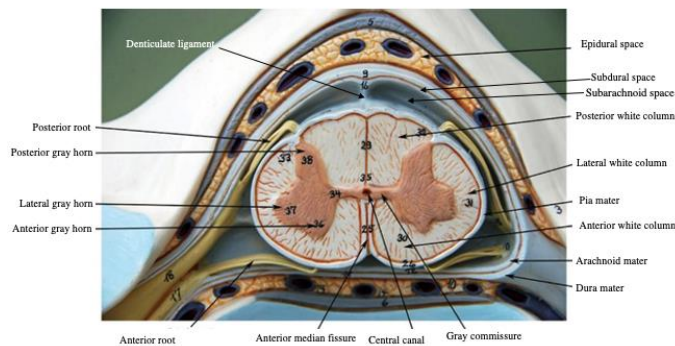
- Meninges

1. Connective tissue layers that surround the spinal cord

2. 3 layers total

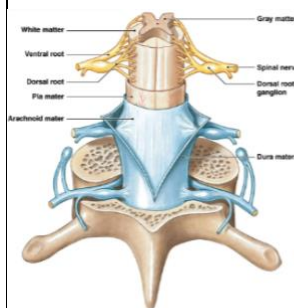
- Dura mater – consists of two fibrous layers. The outermost layers, or endosteal layer, is fused to the periosteum lining the cranial bones. The innermost layer is called the meningeal layer. In many areas the endosteal and meningeal layers are

separated by a slender gap that contains interstitial fluid and blood vessels, including large veins known as dural sinuses. The veins of the brain open into these sinuses, which in turn deliver that blood to the internal jugular vein of the neck.

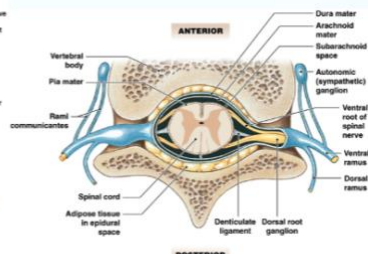


- Arachnoid mater – delicate membrane covering the brain and lying between the superficial dura mater and deeper pia mater, which is in contact with the neural tissue of the brain and spinal cord.

- Pia mater – the thinnest of the membranes. It is tightly attached to the surface of the brain, following its contours and lining the sulci. The pia is anchored to the surface of the brain by the processes of astrocytes.



Posterior view of the spinal cord showing the meningeal layers, superficial landmarks, and distribution of gray and white matter

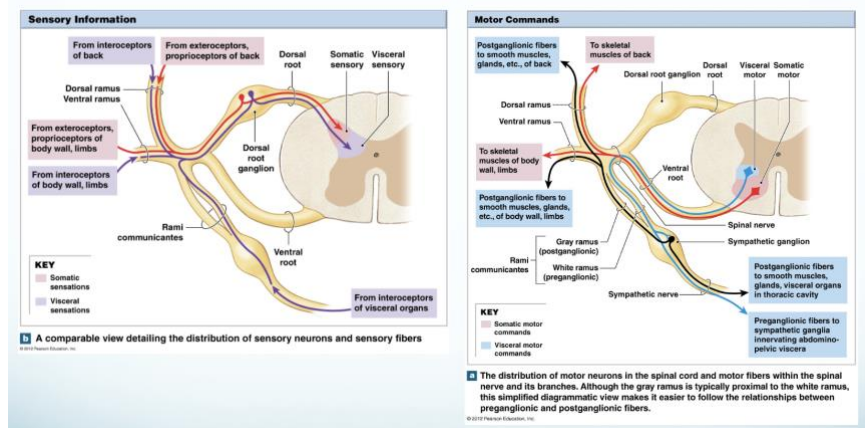


Sectional view through the spinal cord and meninges showing the peripheral distribution of the spinal nerves

- Cranium – the braincase; the skull bones that surround the brain.
 - CSF – cerebrospinal fluid; fluid bathing the internal and external surfaces of the CNS; secreted by the choroid plexus.

- Spinal nerves
 - Spinal nerves are connected to the spinal cord
 1. A total of 31 pairs
 2. Bring sensory information from receptors to the spinal cord
 3. Bring motor information from spinal cord to muscles and glands
 - Spinal nerve structure
 1. Roots
 - i. Dorsal (posterior) root
 1. Bring in sensory information from the periphery
 - ii. Ventral (anterior) roots
 1. Send out motor information to all the skeletal muscles as well as the visceral muscles
- Gray matter
 - Processing of sensory input and motor output
 1. Dorsal (posterior) gray horns
 - Process sensory information
 2. Ventral (anterior) gray horn
 - Send out somatic motor information
 3. Lateral gray horn
 - Send out visceral motor information
- White matter
 - Subdivided into three sections
 1. Dorsal white columns
 2. Ventral white columns
 3. Lateral white columns
 - Each contains bundles of axons called tracts
 - Ascending tracts – send signals toward the brain
 - Descending tracts – send signals away from brain
- Processing of sensory information
 - A series of steps help with processing
 1. Sensory receptors detect a stimulus.

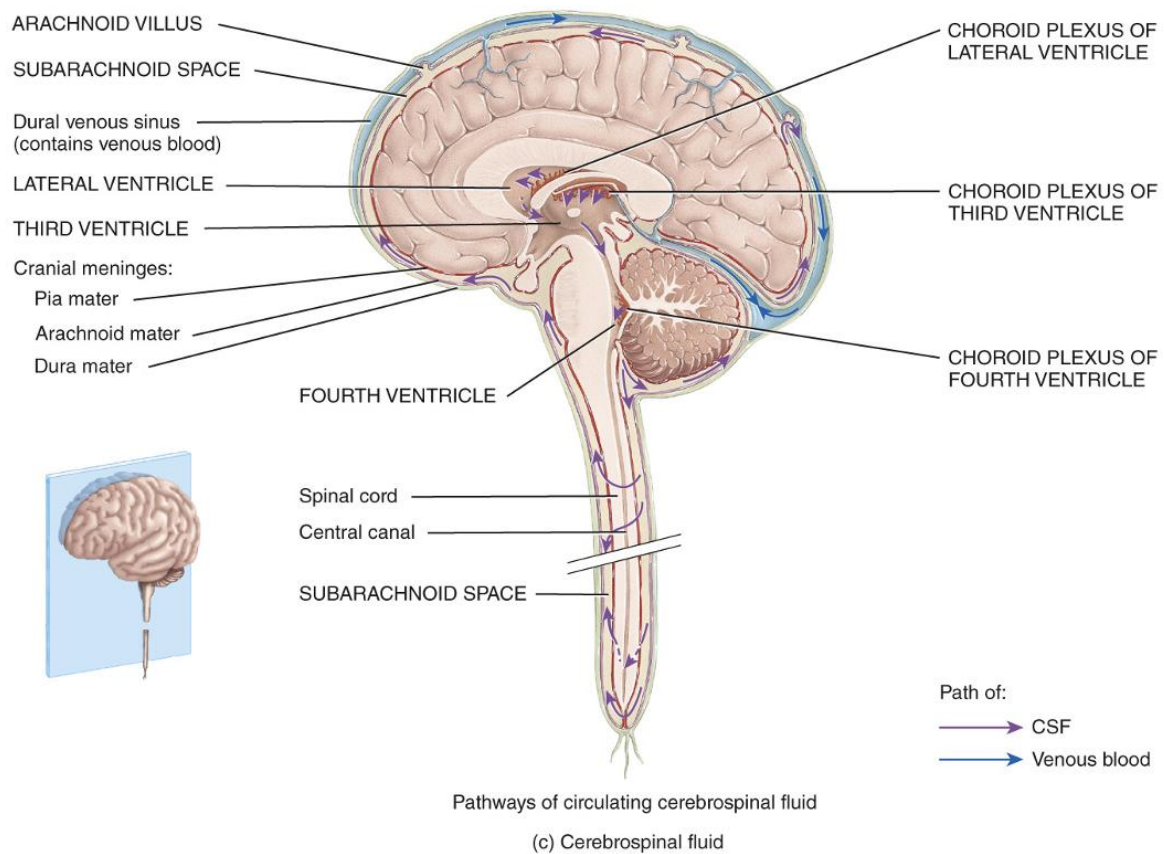
2. Sensory neurons convey this sensory input in the form of action potentials into the spinal nerve and then into the dorsal root.
 - From the dorsal root, axons of sensory neurons:
 - i. Axons of sensory neurons may extend into the white matter of the spinal cord and ascend to the brain as part of a sensory tract.
 - ii. Axons of sensory neurons may enter the dorsal gray horn and synapse with interneurons whose axons extend into the white matter of the spinal cord and then ascend to the brain as part of a sensory tract.
 - iii. Axons of sensory neurons may enter the dorsal gray horn and synapse with interneurons that in turn synapse with somatic motor neurons that are involved in spinal reflex pathways.
 - Motor output from the spinal cord to skeletal muscles involves somatic motor neurons of the ventral gray horn.
 - Somatic motor neurons convey action potentials along their axons to skeletal muscles of the body.
 - Motor output from the spinal cord to cardiac muscle, smooth muscle, and glands involves autonomic motor neurons.
 - While passing through the spinal nerve, axons of the autonomic motor neurons from the spinal cord synapse with another group of autonomic motor neurons located in the peripheral nervous system.



4. Brain

- Meninges (see description above for the spinal cord #3)
 - Three layers
 1. Dura mater
 2. Arachnoid mater
 3. Pia mater
- Blood brain barrier
 - Specialized capillaries
 1. Structural component
 - Tight junctions
 - Astrocytes
 - i. Secrete chemicals to maintain tightness
 2. Functional component
 - Specialized membrane transporters to allow only some water-soluble substances through
 - i. Very selective
- Cerebral spinal fluid
 - Clear and colorless
 - Protects from chemical and physical injury
 - Continuously circulates through various openings in the brain and subarachnoid space
 - Produced by choroid plexus
 - Circulation
 1. CSF route (mnemonic: LIT AF)
 - I. Lateral ventricle
 - II. Interventricular foramen
 - III. Third ventricle
 - IV. Aqueduct of midbrain (cerebral aqueduct)
 - V. Fourth ventricle
 - VI. Central canal (spinal cord)
 2. Functions
 - Mechanical protection

- Shock absorbing
- Chemical protection
 - Optimal chemical environment



- Functions
 - Brain structures
 - Brain stem – contains important processing centers and relays information to and from the cerebrum or cerebellum.
 - Made up of three parts
 - Midbrain (also known as mesencephalon)
 - Upper portion of the brain stem
 - Nuclei
 - Substantia nigra
 - Red nucleus
 - Superior and inferior colliculi
 - Functions
 - Process visual and auditory information

- Generation of reflexive somatic motor responses
- Maintenance of consciousness
- ii. Pons
 1. Middle portion of the brain stem
 2. Nuclei
 - Pontine nuclei
 - Pontine respiratory group
 3. Functions
 - Relays sensory information to cerebellum and thalamus
 - Subconscious somatic and visceral motor centers
- i. Medulla oblongata
 1. Lower portion of the brain stem
 2. Nuclei
 - Cardiovascular center
 - Respiratory center
 3. Functions
 - Relays sensory information to thalamus and to other portions of the brain stem
 - Autonomic centers for regulation of visceral function (cardiovascular, respiratory, and digestive system activities)
- Cerebellum
 - Evaluates how well the movements initiated by the motor areas are being carried out.
- Diencephalon
 - Composed of three parts
 1. Thalamus
 - Upper part of diencephalon
 - Consists of masses of gray matter
 - Relays most sensory input to and from the cerebral cortex
 2. Hypothalamus
 - Has many nuclei that control body functions

- Control of autonomic nervous system (ANS)
- Production of hormones
- Regulation of emotional behavior patterns
- Regulation of eating and drinking
- Control of body temperature
- Regulation of circadian rhythms
- 3. Pineal gland
 - Pea sized gland behind the thalamus
 - Secretes melatonin
 - Controls sleep/wake cycles
- Cerebrum
 - Largest part of the brain
 - Called the seat of intelligence
 - Functions
 1. Conscious thought processes, intellectual functions
 2. Conscious and subconscious regulation of skeletal muscle contractions
 3. Memory storage and processing
 - Structure
 1. Outer most layer is gray matter
 2. Cerebral cortex
 - Arranged in 6 layers
 3. Middle layer composed of white matter
 4. Inner area composed of gray matter arranged as nuclei
 5. Hemispheres
 6. Gyri
 7. Sulci

8. Lobes -

- Frontal – where the primary motor cortex is located; conscious control of skeletal muscles
- Parietal – where the primary sensory cortex is located; conscious perception of touch, pressure, vibration, pain, temperature, and taste

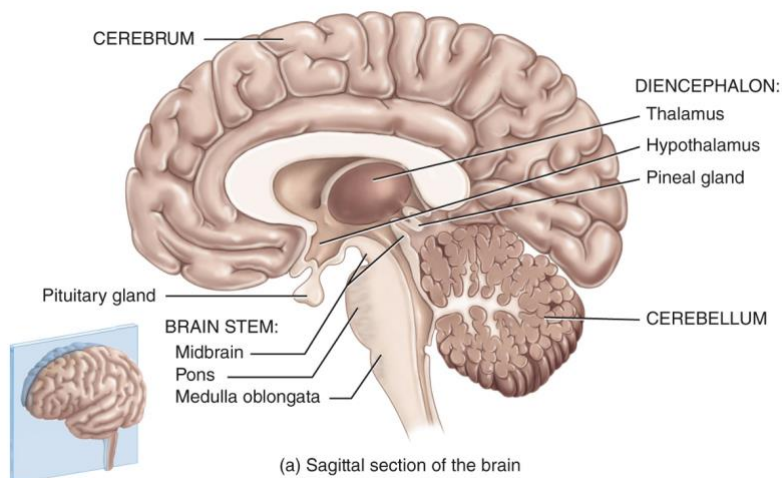
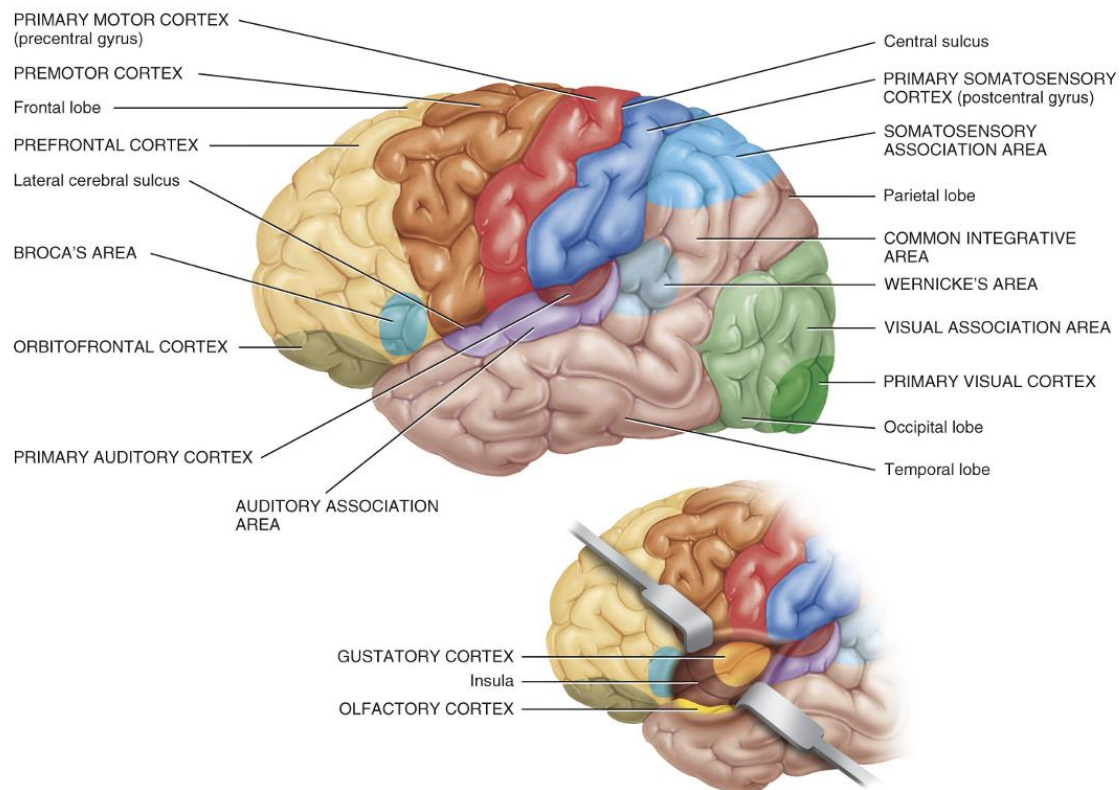
- Occipital – where the visual cortex is located; conscious perception of visual stimuli
 - Temporal – where the auditory and olfactory cortices are located; conscious perception of auditory and olfactory stimuli
 - Sensory areas
 1. Primary somatosensory cortex
 - Located in the postcentral gyrus of the parietal lobe.
 - Receives sensory information for:
 - i. touch
 - ii. pressure
 - iii. vibration
 - iv. temperature (coldness and warmth)
 - v. pain
 - vi. proprioception (muscle and joint position)
 - Primary visual cortex
 - i. located in the occipital lobe
 - ii. receives visual information
 - Primary auditory cortex
 - i. located in the temporal lobe
 - ii. receives information for sound
 - Gustatory cortex
 - i. located in the insula
 - ii. receives information for taste
 - Olfactory cortex
 - i. located on the inner surface of the temporal lobe
 - ii. receives information for smell
- Motor areas
 1. Primary motor cortex
 - Located in the precentral gyrus of the frontal lobe.
 - Each region in the primary motor cortex controls voluntary contractions of specific muscles or groups of muscles.
 - i. Contralateral control

2. Broca's area
 - In frontal lobe
 - Involved in the articulation of speech
- Association areas – adjacent to primary areas (present in all lobes)
 1. Somatosensory association area
 - Develops memories to somatosensory experiences
 2. Visual association area
 - Evaluates what is seen
 3. Facial recognition area
 - Allows you to recognize people by their faces
 4. Auditory association area
 - Allows you to recognize a particular sound
 5. Orbitofrontal cortex
 - Allows you to identify and discriminate smells
 6. Wernicke's area
 - Interprets the meaning to words
 7. Common integrative area
 - Takes information from other sensory areas to form thoughts
 8. Prefrontal cortex
 - Personality, intellect, complex learning etc.
 9. Premotor cortex
 - Serves as a memory bank for complex movements
 10. Basal nuclei
 - Functions
 1. Subconscious control and integration of skeletal muscle tone
 2. Coordination of learned movement patterns
 3. Processing, integration, and relay of information from the cerebral cortex to the thalamus
 - Gray matter masses
 - i. Globus pallidus
 - ii. Putamen
 - iii. Caudate nucleus

- Limbic system

1. Several structures (cerebrum, diencephalon, and mesencephalon) playing a role together in many different emotions

- Establishment of emotional states and related behavioral drives
- Linking the conscious, intellectual functions of the cerebral cortex with the unconscious and autonomic functions of other portions of the brain
- Facilitating memory storage and retrieval



The Autonomic Nervous System

- Regulates the activity of smooth muscle, cardiac muscle, and glands
 - Referred to as the visceral organs
- Will either increase or decrease ongoing activities
 - Excitation
 - Inhibition
- Composed of three branches
 - Sympathetic branch
 - Parasympathetic branch
 - Enteric branch
- Most organs receive dual innervation (sympathetic/parasympathetic)
- Enteric innervates the gastrointestinal tract
- The Autonomic Nervous System – functions
 - Very diverse
 - Autonomic tone
 - Constant innervation by both branches
 - 1. To get desired effect one will turn up while the other turns down
 - Parasympathetic effects
 - 1. Rest and digest
 - 2. Conserve body energy
 - 3. Promote the breakdown and absorption of food
 - 4. Remember SLUDD
 - Salivation
 - Lacrimation
 - Urination
 - Digestion
 - Defecation
 - Sympathetic effects
 - 1. Fight or flight
 - Very diffuse and affects many organs
 - Longer lasting than parasympathetic effects